

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
14 June 2001 (14.06.2001)

PCT

(10) International Publication Number  
**WO 01/42622 A1**

(51) International Patent Classification<sup>7</sup>: **E21B 47/12**,  
23/08, 47/00

(21) International Application Number: PCT/GB00/04709

(22) International Filing Date: 8 December 2000 (08.12.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
9929180.9 9 December 1999 (09.12.1999) GB

(71) Applicant (for all designated States except US): **OXFORD INSTRUMENTS SUPERCONDUCTIVITY LIMITED** [GB/GB]; Old Station Way, Eynsham, Witney, Oxon OX8 1TL (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **HAWKES, Robert,**

Carter [GB/GB]; Derrymore House, 3 Old Rectory Drive, Dry Drayton, Cambridge CB3 8BU (GB). **WILKINSON, Adam, Archer** [GB/GB]; Bridge View, Green Lane, Thetford, Norfolk IP24 2EX (GB).

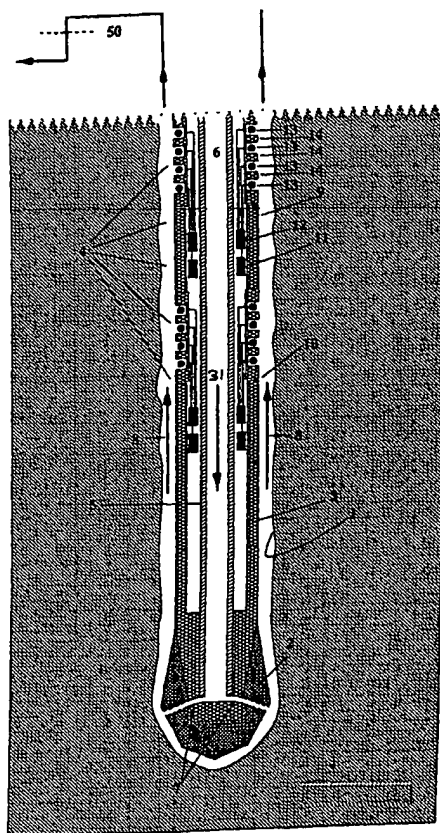
(74) Agent: **GILL JENNINGS & EVERY**; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,

[Continued on next page]

(54) Title: METHOD AND DEVICE FOR TRANSFERRING DATA



(57) Abstract: A method of transferring data relating to information obtained by a sensor from within a bore. The method comprises: downloading the data from the sensor (9, 10) into a data store (40) in a transfer unit (13), while the sensor is located in the bore; and, causing the transfer unit (13) to be conveyed by a fluid medium along the bore to a remote position.

WO 01/42622 A1



IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *With international search report.*

METHOD AND DEVICE FOR TRANSFERRING DATA

The invention relates to a method and device for transferring data relating to information obtained by a sensor from within a bore. For example, the invention has particular application to the transfer of data from within an oil or gas borehole.

Information about the formation around a bore hole can be obtained separately from the drilling operation by removing the drill and then inserting one or more sensors on a wire line which are operated to gather information.

Measurement whilst drilling (MWD) and logging whilst drilling (LWD) techniques permit measurement of earth formation properties and mechanical properties of the drilling process. They have been developed to monitor characteristics of the borehole, its surroundings and the drilling process during the drilling operation. In order to provide some form of real-time feedback, advantage has been taken of the fact that drilling mud is caused to flow down the centre of the drill string and then up around the drill string and a valve through which the drilling mud passes has been pulsed appropriately in accordance with the sensed data so that this pulsed code can be detected at the surface and the data extracted.

MWD (usually taken to mean a measurement for direct use) and LWD (usually taken to mean measurements recorded for later use) can be used to provide real-time dynamics of the drill string motion, directional drilling data and formation evaluation. Formation evaluation whilst drilling or whilst the drill string is in place is particularly valuable in applications where there is a high risk that repeated excursions into the borehole may result in equipment failure, where orientation of the sensors relative to the borehole is important and wire-line tools (inserted after the drilling process) may have to be conveyed by drill pipe or tubing. This includes the opportunity to measure whilst drilling as well as in any

gaps between drilling activity, and as the drill string is extracted.

The earth formation properties may be deduced from measurements of natural Gamma Rays , formation resistivity, Neutron back-scatter, Gamma Ray Compton scattering, nuclear magnetic resonance response and acoustic properties.

Drilling performance can also be measured and used to enhance directional control and drilling efficiency. If conveyed to the surface, this information can aid real-time directional control. Other parameters measured and of use at the surface are down-hole pressure, temperature, down-hole weight on bit and torque on bit and down-hole vibration and shock.

Although there are considerable advantages as set out above for operating MWD and LWD, these systems are limited by the relatively slow rate at which information can be transferred to the surface. Typically, the maximum rate is about 1 bit per second using pulsed mud. It is not desirable to increase the bit rate since this could modify the mud flow in such a way as to adversely affect its other actions. This slow bit rate also limits the rate that additional sensing instruments provided on the drill string send information in real time to the surface.

In accordance with one aspect of the present invention, a method of transferring data relating to information obtained by a sensor from within a bore comprises:

a. downloading the data from the sensor into a data store in a transfer unit, while the sensor is located in the bore; and

b. causing the transfer unit to be conveyed by a fluid medium along the bore to a position remote from the sensor.

With this invention, we can significantly increase the rate at which data is transferred from the sensor by making use of a number of transfer units into which data is regularly transferred from the appropriate sensor, the

transfer units then being conveyed by a fluid medium, for example drilling mud, to the remote position, typically at the well head.

5 The term bore is normally intended to refer to a hole drilled in the earth. However, in the present invention the bore could be any form of aperture into which the sensor could be positioned. The bore could therefore include tubes, pipes and the like.

10 The amount by which the data transfer rate increases over conventional methods will depend on the capacity of the data store, the flow rate of the fluid medium, and the distance the transfer unit must be conveyed until it reaches the remote position. We believe, however, that with transfer units in the form of electrically contactless  
15 memory chips which currently include about 8K bytes of non-volatile memory, a significant increase in the data transfer rate can be achieved. Furthermore, these chips can be embedded within a protective and resilient casing which can withstand the harsh treatment to which the  
20 transfer unit will be exposed during its passage to the remote position. And finally the data can be extracted at the remote position, in a contactless way, without precise positioning of the transfer unit and the transfer units are ultimately available for reuse if collected.

25 The non-volatile memory is usually in the form of an EPROM, although EEPROMs or the like could also be used.

Typically, the sensor will be mounted to a drill string in the case of MWD and LWD but the invention is also applicable to any simple logging system deployed within the  
30 borehole. In some cases, the transfer unit itself could include the sensor. However, this would lead to a more complex construction for the transfer unit which is less desirable.

In some cases the transfer unit could be dismantled to  
35 retrieve the data store or a reader could make electrical connection with the datastore via exposed contacts. Preferably, however, in order to reduce the possibility of

unreliability and/or damage to the electrical components of the transfer unit, preferably step (a) comprises inductively transferring data from the sensor to the data store. This avoids the need for any electrical contact  
5 connection between the sensor and the data store.

The transfer unit could store data from a single sensor or more than one sensor.

Typically, the method further comprises repeating steps (a) and (b) with further transfer units. This  
10 enables data from other sensors or further data from the same sensor but at a later time to be transferred to the remote position. In addition, this allows the same data to be transferred to the data stores of successive transfer units in each repeated step (a). This latter approach  
15 reduces the risk of loss of data if a transfer unit is not retrieved or destroyed as may happen in the harsh environment of down-hole well drilling, thus any required degree of redundancy can be established. Preferably the method further comprises the step of:

20 c. extracting data from the data store.

In this case, the transfer units may simply be collected at the remote position, and then placed either manually or under robotic control in a suitable reading device which enables the data to be extracted from the data  
25 stores. Extraction could be achieved by filtering the returning fluid or alternatively, the fluid could simply be transferred into the region surrounding the bore hole opening so that the data stores can be collected from the ground. In the preferred approach, however, the transfer  
30 units are passed from the remote position along a path through a reading device for extracting data from the data stores whilst they are still immersed in the returning fluid. In order to reduce the possibility of damage to the electrical components of the transfer unit this step may  
35 comprise inductively transferring data from the data store to the uphole electronics. This avoids the need for any

electrical contact. This leads to a more automated retrieval of data.

In some cases, the transfer units could be partly magnetic or made buoyant to enable them to be more easily separated from the medium. Furthermore, where more than one sensor is provided, the transfer units could be colour coded or otherwise made distinguishable according to the origin of the data they carry. The identification could also be used to provide an indication of the order in which the transfer units have been released. This could be a simple sequential numbering scheme or a more complex form of identification.

In accordance with a second aspect of the invention, a bore logging tool data transfer device comprises a support attached in use to at least one bore logging tool sensor; a transfer unit holding section located on the support and having a size to hold at least one transfer unit, the transfer unit including a data store; a retainer for releasably holding a transfer unit in the transfer unit holding section; and a transfer system for transferring data from any bore logging tool sensor to the transfer unit store.

Preferably, the transfer unit holding section is recessed into a housing of the device so that there is little effect on the action of the tool or damage to the transfer unit.

The retainer normally comprises a plug releasably mounted to the transfer unit holding section, and means for releasing the plug. In this case the means for releasing the plug typically comprises an explosive charge. Alternatively the plug may be released magnetically. This could be achieved either by providing the plug with a magnetic field and then applying a field with a like polarity to the plug to repel it from the transfer unit holding section. A further alternative is to provide the transfer unit holding section with an extraction member

which pushes the plug away from the holding section. Again this may be magnetically actuated.

As mentioned above, a plurality of transfer unit holding sections may be provided for releasably holding  
5        respective transfer units. In some cases, each transfer unit holding section is adapted to hold a single transfer unit but in other cases, the transfer unit holding section may comprise a magazine for holding a number of such units which are sequentially released.

10        An example of a method and device according to the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a schematic cross-section through part of a borehole and a MWD tool;

15        Figure 2 is a schematic view of an example of a transfer unit holding section;

Figure 3 is a cross-section through a transfer unit;

Figures 4A and 4B illustrate schematically the reading and writing electronics respectively; and,

20        Figure 5 illustrates an example of a reading device in more detail.

Figure 1 illustrates part of a down-hole well having a bore 1 into which is inserted a drill head 2 attached to a drill collar 3 which includes a sensor and communication  
25        section 4. A mud pipe 5 with a clear central bore 6 extends down the centre of the tool. In use, the drill head 2 can be rotated by rotating the entire tool using a drive on the surface while drilling mud is pumped down the mud pipe 5. Additionally, the drill head can be rotated  
30        relative to the drill pipe by the action of a mud driven turbine. The mud exits through apertures 7 and returns around the tool as shown by arrows 8.

In this example, two sensors 9,10 are provided in the sensor and communication section 4. The sensors are only  
35        illustrated schematically in Figure 1 since they will be well known to a person of ordinary skill in the art. The sensing device 9 comprises an acoustic logging device while



the sensing device 10 comprises a formation resistivity sensor.

5 The sensing device 9 includes sensing electronics 11 and the like for sensing acoustic properties of the surrounding formation and is controlled by a microprocessor 12. The microprocessor 12 regularly samples the received signals and feeds these to a selected transfer unit 13 in one of four transfer unit holding sections 14.

10 An example of a transfer unit holding section is shown in more detail in Figure 2. The transfer unit holding section comprises a recess 20 formed in a ceramic or resin jacket 21 which extends along a section of the tool adjacent to the sensor in section 4. An annular groove 22 is provided in the wall of the recess 20 and this receives  
15 a corresponding annular flange 23 of a retaining cap 24. The inner surface 25 of the cap 24 and the surface of the recess 20 are correspondingly shaped to define a space 26 in which a transfer unit or "marble" 13 is retained.

20 An inductive coupling loop 27 is embedded in the jacket 21 and extends around part of the cavity 26 and is connected by wires 28 to the microprocessor 12.

The rear of the cavity 26 is defined by a moulded explosive ejection charge 29 which can be triggered by the microprocessor 12 via wires 30. The rear of the transfer  
25 unit holding section is defined by a stainless steel pressure housing 31.

The construction of the marble 13 is shown in Figure 3. This comprises a MIFARE MF2ICD80 smart card IC 40 located at the centre of a spherical body 41 formed from  
30 protective and resilient ceramic or resin and at the base of a bore 42 filled with a resin plug 43 keyed in position via a groove 44. The smart card IC 40 includes an aerial or coupling loop 45.

35 When the microprocessor 12 wishes to transfer data to the surface, the data is extracted from the sensing electronics 11 and passed to a selected one of the transfer unit holding sections 14. The data is supplied along lines

28 to the appropriate coupling loop 27 where it is inductively coupled into the smart card IC 40 of the corresponding marble 13 and stored in non volatile memory in the chip. Figure 4B illustrates the data transfer electronics in more detail where it can be seen that the microprocessor 12 communicates with a MIFARE ISO14443A interface IC 60. Optionally, the microprocessor 12 may store a time stamp and/or an indicator of the sensor from which the data has been supplied. Alternatively, the marble may have pre-stored in it identification information.

Once the data has been stored, the microprocessor 12 sends a signal along the lines 30 to activate the explosive charge 29 which forces the marble 13 radially outwardly, breaking the flange 23 of the cap 24 thus releasing the marble 13 into the upward flow 8 of the drilling mud.

The marble 13 is conveyed up the bore 1 and is collected by passing the retrieved mud through a filter 50, the filtered mud then being discarded or reused.

Alternatively, the mud may be allowed to flow on to the ground surrounding the bore hole allowing the marble 13 to be collected from the ground.

The collected marbles are then transferred to a reading device electronically configured as shown in Figure 4A. This will also be provided with a MIFARE ISO14443A interface IC 46 coupled to an inductive loop 47 so that the data in the non volatile memory of the IC 40 can be read and passed to up-hole analysing electronics 49. The data can then be analysed in a conventional manner.

Figure 5 illustrates an alternative reading device in which each marble 13 is caused to flow through a set of three orthogonal helmholtz coupling coils 65-67, the data being extracted from the non volatile memory as the marble flows through the device. The arrangement of the helmholtz coupling coils enables the data to be extracted from the transfer unit 13 without full knowledge of the position or orientation of the transfer unit 13.

CLAIMS

1. A method of transferring data relating to information obtained by a sensor from within a bore, the method  
5 comprising:
  - a. downloading the data from the sensor into a data store in a transfer unit, while the sensor is located in the bore; and,
  - b. causing the transfer unit to be conveyed by a  
10 fluid medium along the bore to a remote position.
2. A method according to claim 1, wherein the fluid medium comprises a liquid.
3. A method according to claim 1, or claim 2, wherein the  
15 bore is defined by a borehole into the earth's formation , the fluid comprising drilling mud.
4. A method according to any of the preceding claims, wherein the sensor is mounted to a drill string.
5. A method according to any of the preceding claims,  
20 wherein the sensor is located in the transfer unit in addition to the data store.
6. A method according to any of the preceding claims, wherein the data comprises one or more of Gamma Ray, resistivity, Nuclear Magnetic Resonance, Neutron, acoustic,  
25 pressure, temperature and drill string motion data.
7. A method according to any of the preceding claims, wherein step (a) comprises inductively transferring data from the sensor to the data store.
8. A method according to any of the preceding claims,  
30 further comprising repeating steps (a) and (b) with further transfer units.
9. A method according to claim 8, wherein the same data is transferred to the data stores of successive transfer units in each repeated step (a).
- 35 10. A method according to any of the preceding claims, wherein the data store comprises a non-volatile memory.

11. A method according to any of the preceding claims, further comprising the step of:

c. extracting data from the data store.

12. A method according to claim 11, wherein the step of  
5 extracting data from the data store comprises passing transfer units from the remote position along a path through a reading device for extracting data from the data stores.

13. A method according to claim 11 or claim 12, wherein  
10 the data is extracted via an inductive process.

14. A bore logging method comprising locating a sensor in a bore of a well; operating the sensor to sense information about the bore and/or its surroundings; and transferring data relating to said information using a method according  
15 to any of the preceding claims.

15. A method according to claim 14, wherein the bore logging method is carried out during a bore drilling operation.

16. A bore logging tool data transfer device comprising a  
20 support attached in use to a bore logging tool sensor; a transfer unit holding section located on the support and having a size to hold at least one transfer unit, the transfer unit including a data store; a retainer for releasably holding a transfer unit in the transfer unit  
25 holding section; and a transfer system for transferring data from the bore logging tool sensor to the transfer unit store; and means for releasing the device such that it is ejected.

17. A device according to claim 16, wherein the data  
30 transfer system includes an inductive coil.

18. A device according to claim 16 or claim 17, wherein the transfer unit holding section is recessed into a housing of the device.

19. A device according to any of claims 16 to 18, wherein  
35 the retainer includes a plug releasably mounted to the transfer unit holding section, and means for releasing the plug.

20. A device according to claim 19, wherein the releasing means comprises an explosive charge.

21. A device according to claim 19, wherein the releasing means comprises a magnetic switch causing ejection.

5 22. A device according to any of claims 16 to 21, wherein a plurality of said transfer unit holding sections are provided for releasably holding respective transfer units.

23. A bore logging tool comprising a transfer device according to any of claims 16 to 22; and a sensor for  
10 sensing information about the bore surroundings and/or the tool motion and for generating corresponding data which is supplied in use to the data transfer systems of the transfer device.

24. A tool according to claim 23, further comprising at  
15 least one transfer unit including a data store, the transfer unit being releasably held by the retainer.

25. A tool according to claim 24, wherein the transfer unit comprises a electrically contactless memory chip.

26. A tool according to any of claims 23 to 25, further  
20 comprising a drilling tool mounted to the support.

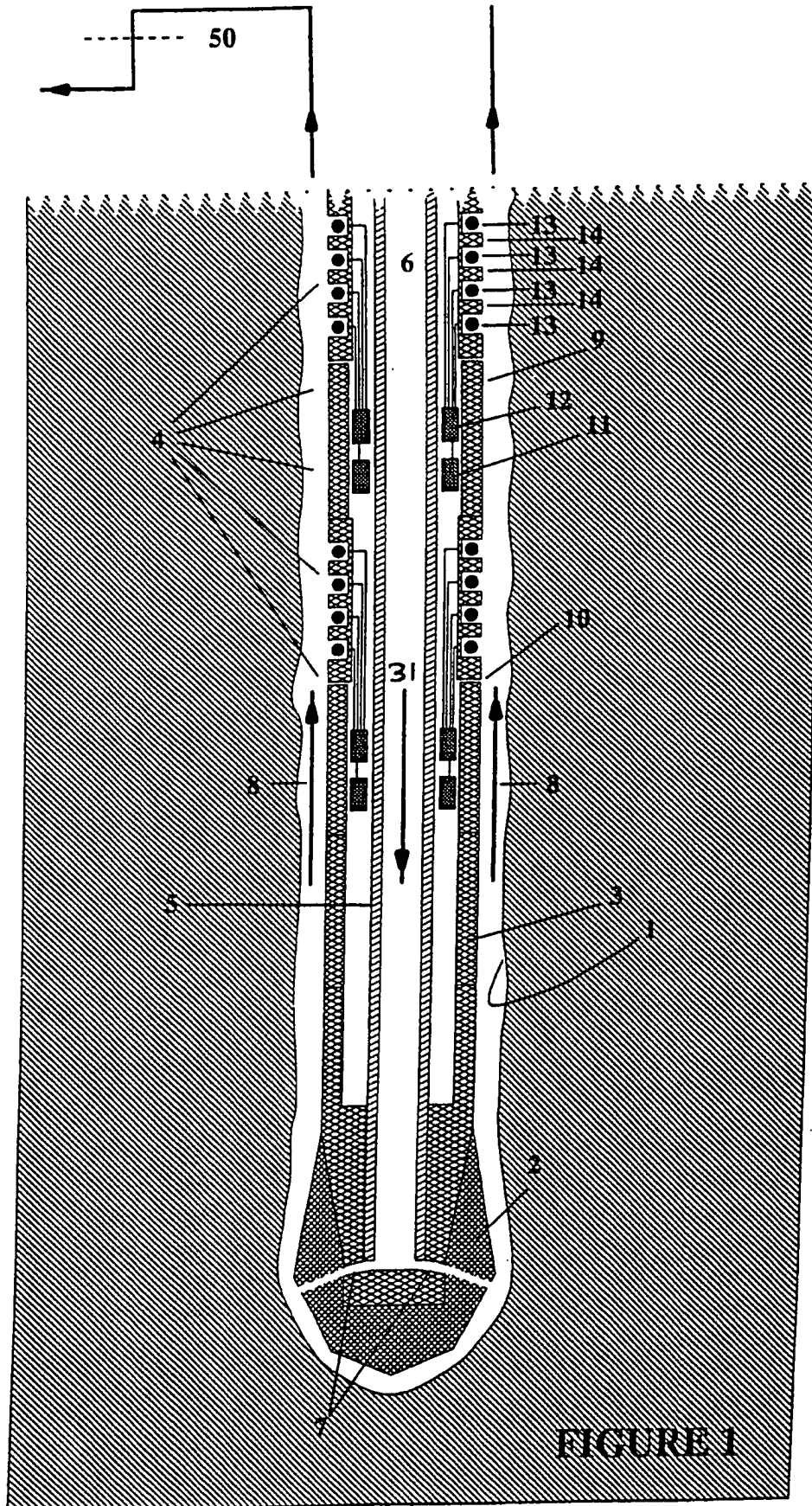
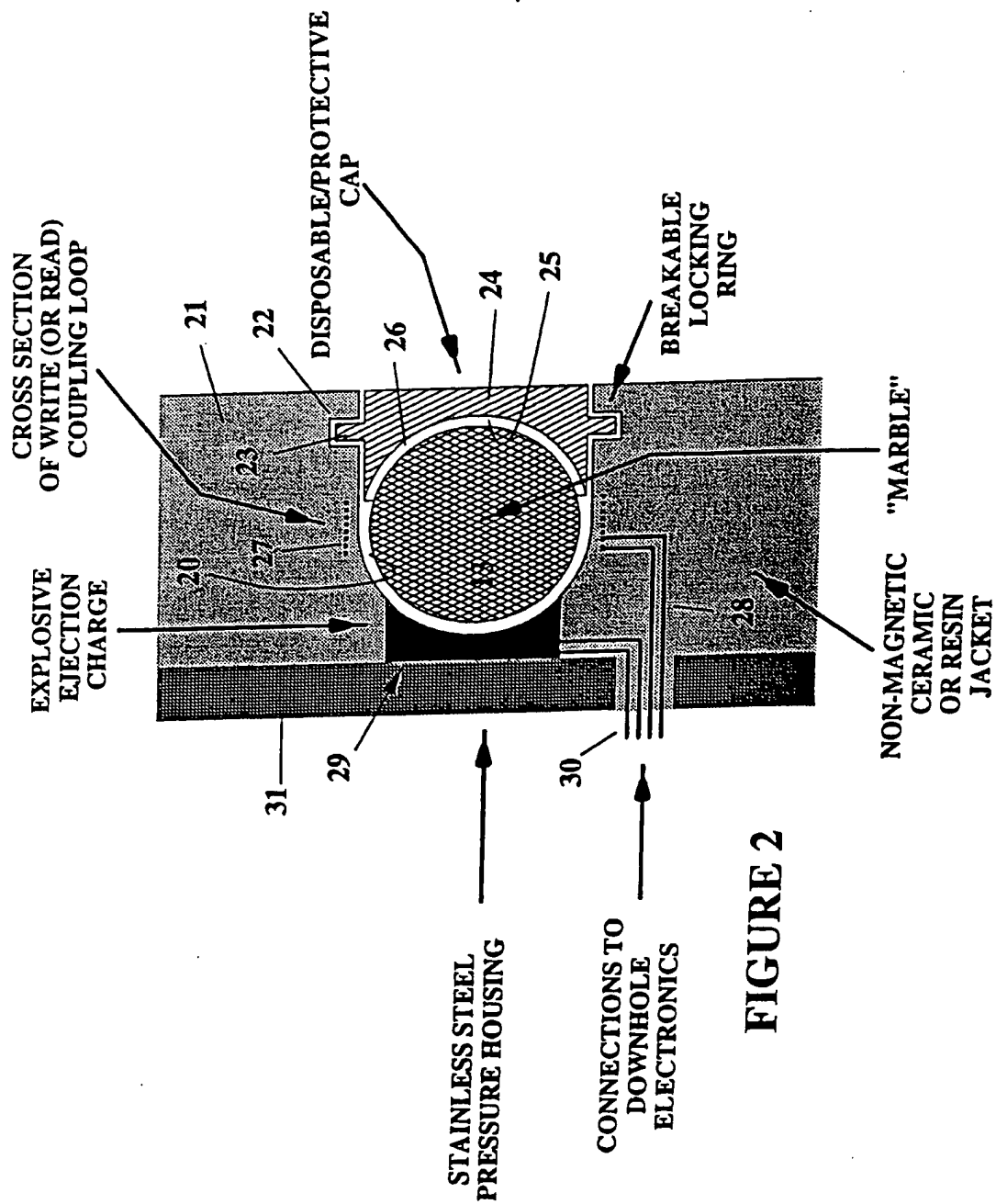
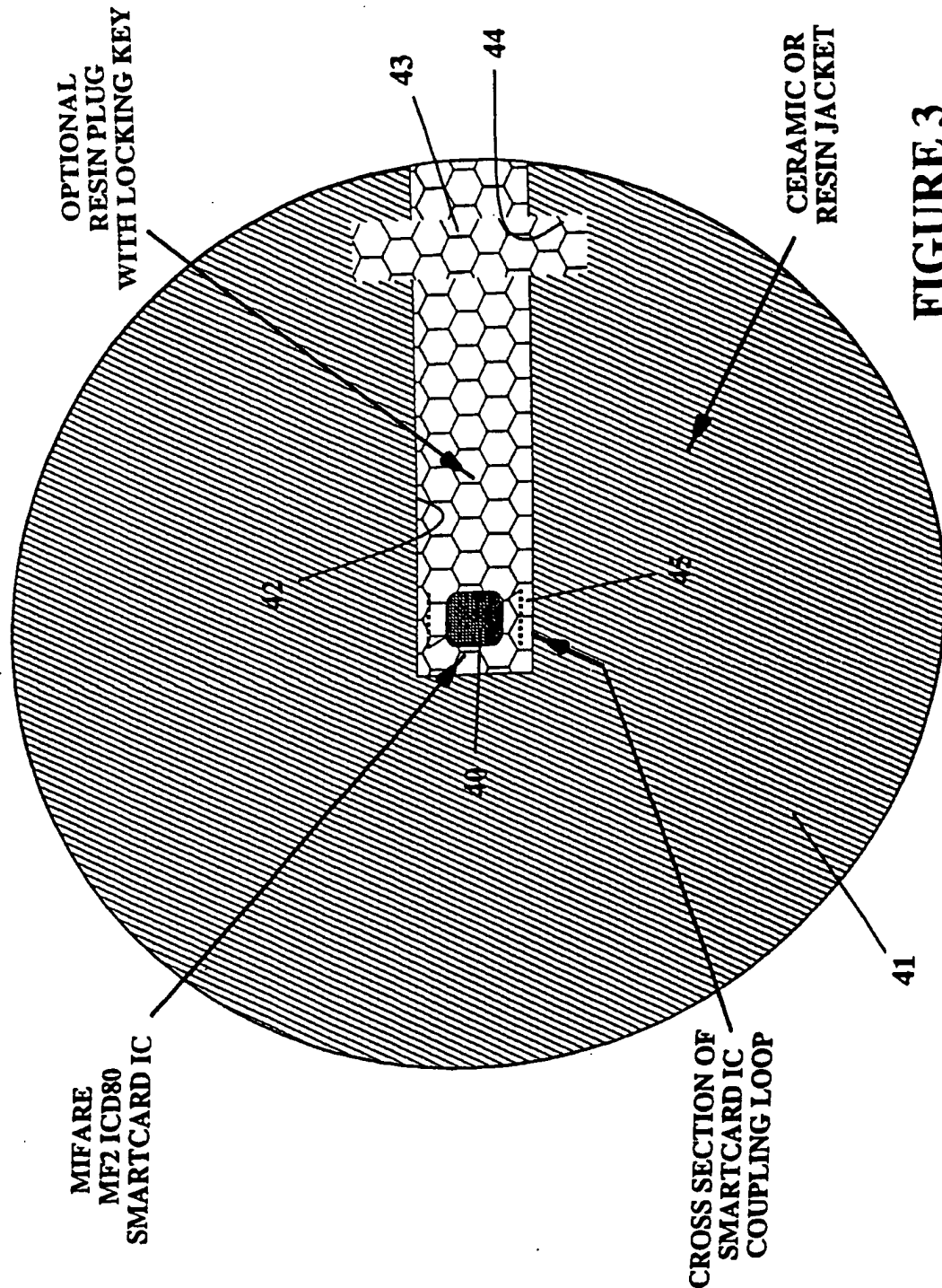


FIGURE 1

2/5

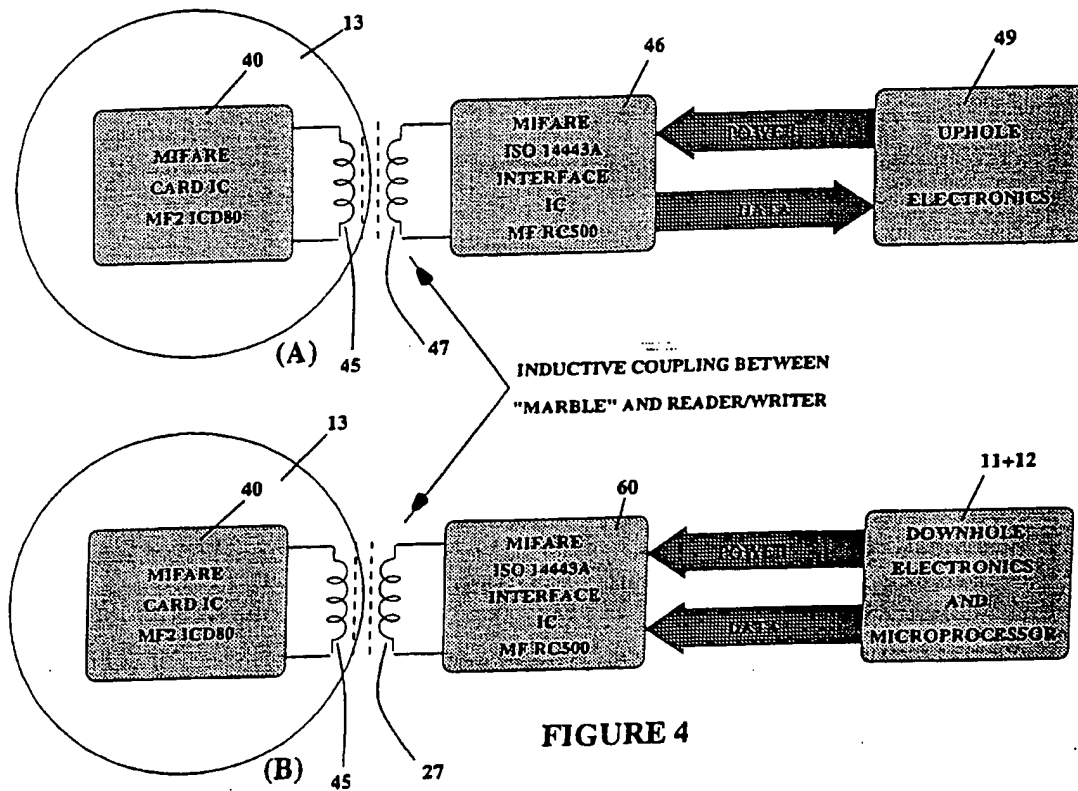


3/5

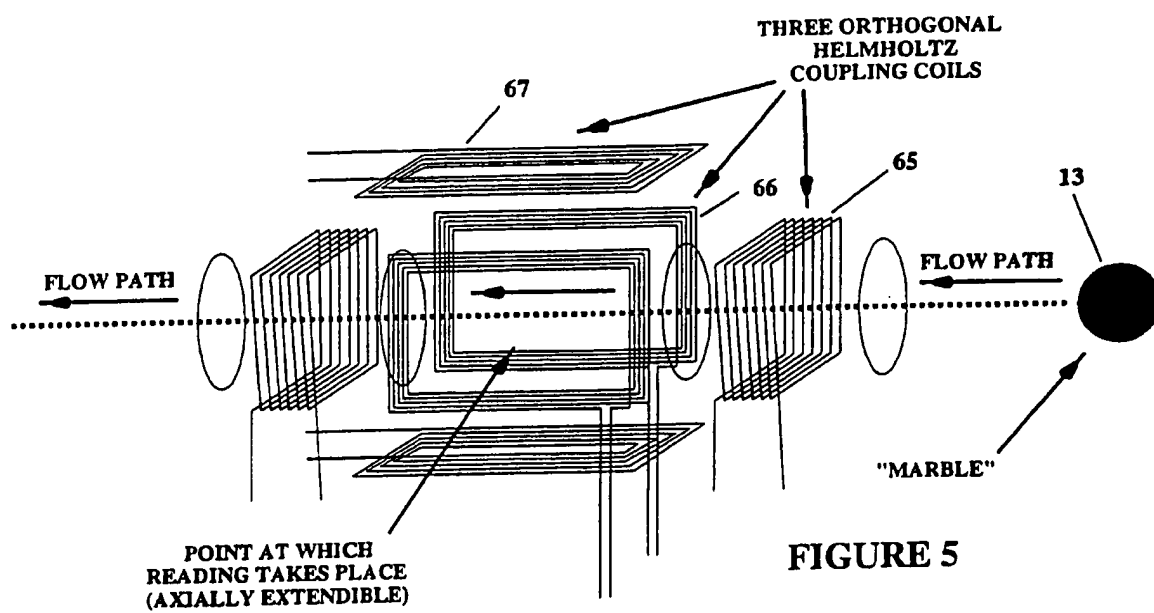




4/5



5/5



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/04709

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B47/12 E21B23/08 ,E21B47/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 23 58 371 A (KOOLAJ FOLDGAZBANYASZATI) 28 May 1975 (1975-05-28) page 4, line 2-11; figure 2 ---	1,16
A	WO 98 12418 A (INTELLIGENT INSPECTION CORP CO) 26 March 1998 (1998-03-26) the whole document -----	1,16



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*G\* document member of the same patent family

Date of the actual completion of the international search

27 February 2001

Date of mailing of the international search report

06/03/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Schouten, A

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/04709

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 2358371	A	28-05-1975	NONE	
WO 9812418	A	26-03-1998	US 5947213 A	07-09-1999
			AU 4589597 A	14-04-1998
			BR 9706796 A	04-01-2000
			CA 2238334 A	26-03-1998
			EP 0862682 A	09-09-1998
			NO 982336 A	22-07-1998
			US 6026911 A	22-02-2000
			US 6112809 A	05-09-2000